A COMPARATIVE ANALYSIS OF TWO COMPUTERIZED METHODS FOR PATIENT HISTORY COLLECTION

by

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SUPERVISORY COMMITTEE APPROVAL

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ABSTRACT

The goal of this thesis is to compare a decision-driven data acquisition questionnaire (DDA) and a hierarchical branching questionnaire to see which format can obtain a history more effectively. Both questionnaires start with a few broad questions relevant to presenting the patient's region of illness. The DDA questionnaire then selects questions to ask the patient depending on the likelihood of the patient having a specific disease state. The hierarchical branching questionnaire uses a branching pattern whereby positive responses lead to more detailed questions on that topic. The histories were given to the patients. After collecting the patient histories, the following features were examined: the number of questions each history asked, the amount of time each history took, the accuracy of the history, and the patient reaction to using a computerized history. The best report format possible was designed for the physician's report. The physician's reaction to the history was requested.

This process took place within the HELP (Health Evaluation through Logical Processing) computer system at LDS Hospital. The patient histories were collected from July of 1985 through July of 1986. Forty-one patients participated in the computer-directed history study. Twenty-one of the patients used the hierarchical questionnaire and 20 patients took the DDA history. Three incomplete histories had to be excluded. Fourteen patients returned the paper questionnaire with their opinion of taking a computerized history. Three physician comments were received.

In examining the number of questions each history asked and the amount of time each took, it was found there was a significant difference between the DDA and hierarchical methods. The DDA took a mean time of 12 minutes and asked an average of 91 questions,

In examining the number of questions each history asked and the amount of time each took, it was found there was a significant difference between the DDA and hierarchical methods. The DDA took a mean time of 12 minutes and asked an average of 91 questions, while it only asked on average 56 NO response questions per patient. The hierarchical method took a mean time of 22 minutes, asked an average of 181 questions, and asked an average of 145 NO response questions per patient. The reduction in the number of questions asked to the patient taking the DDA history is due to fewer number of NO response questions being asked (89 ± 15).

For 42% of the patients who took the history, there was not a help frame to For the 22 discharge diagnosis where there was a frame availible, the program was correct 11 times or 50% (45% with the DDA, 55% with the hierarchical). There was no significant difference in having the discharge diagnosis on the diagnostic list between DDA and branching methods.

The Chief Complaint area obtained with the patient history programs agreed with the discharge diagnosis chief complaint 87% of the time with the DDA program and 61% of the time with the hierarchical method. This shows although the history only had the patient's discharge diagnosis on its diagnostic list 50% of the time, it was able to identify the area of the patient's major problem to focus its questioning.

In summary, the goal of obtaining a computerized history for a patient chart was achieved. It has been shown the DDA process took significantly less time and asked fewer questions than the hierarchical method, while maintaining the same level of accuracy. The patient response to the computerized history was favorable.

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CHAPTER 1

INTRODUCTION

The Problem: Collecting a Medical History

The history and physical examination are the most important sources of information from which a patient diagnosis is made (1,2,3,4). They provide valuable information which can improve the efficiency and effectiveness of the medical care the patient receives. The reliability of medical record information is of fundamental importance to the quality care of the patient.

The patient medical history is the collection of a database upon which the diagnosis and the patient management decisions are based. The medical history includes the collection of information of the present complaint, a general review of systems (physiological and psychological systems), and a review of environment (e.g., allergy, occupational , family, and social history) and demographic information. There is a lack of standardization and great variability in the organization of the patient history (e.g., problem oriented, time-oriented, source oriented) by physicians.

There are several advantages to the health care providers and to the patient in the development of a computer assisted collection of a patient history. A computerized history could : 1) Save the physician time. This would allow better utilization of the physician's time, as medical history taking is considered to be the most time consuming part of primary care. 2) Increase the legibility and standardization of the patient records. This would result in more effective communication between health care professionals about the patients'

problems and needs. 3) Minimize the interviewer bias. It has been shown the physician tends to edit the history, as the medical record is written, to contain what he considers is clinically significant and supports his diagnosis (2,5,6). 4) Establish a patient database with improved documentation and increase the availability of the patient data. A patient database would be beneficial to both the patient and health care providers. A patient data base could improve the patient quality of care by serving as a base that can be updated as a patient's care continues rather than be repeated with each admission and a base upon which a patient alerting system can be implemented. The patient history contains information vital for the development and use of patient alerting systems.The hospital benefits from the improved ability to retrieve information for data gathering tasks in periodic review by governmental or organizational review groups. A computerized database allows a rapid and effective search of standardized records. A computerized database of patient information and symptoms in various disease states would serve as an excellent database for clinical research.

While computer systems have been successful in collecting quantitative data (e.g., white blood cell counts collected directly from instruments), the collection of qualitative data (e.g., history and physical examination) has been more elusive (7). The problems in collecting a computerized medical history begin with the lack of standardization or definition of what an effective patient history should include (8). This is complicated with the complexities involved in collecting a patient history. It has been questioned if taking a patient history is an art form of physicians that is developed over time, based on intuition and instinct, that rules cannot replace(7). In choosing questions to ask a patient to obtain a relevant history, one has to consider the broad range of symptoms that have to be evaluated as a possibility [3262 medical conditions or diseases are described in standard medical texts (9)]. One has to collect a history that is both a general overview of all systems and then detail the patient problem area. Also there is a problem in the complexities of programming a computer to mimic the natural language processes. When two people are exchanging information, one

may answer a question with additional information that will divert the conversation to a different path. The exchange between two people does not always follow any kind of logical process and is hard to imitate. The last problem area is in the man/machine interface areas, and the computer taking a patient history cannot receive the nonverbal messages the patient is sending. The patient cannot explain the importance to the computer of which symptoms are especially troublesome by the intonation of his voice. There is also a problem at the computer/physician interface. The computer will print out all of the information it has collected. This is sometimes at the expense of the clinically important information as the report form becomes too long or general to be practically workable (6).

The major goal of this thesis is to compare a decision-driven data acquisition questionnaire and a hierarchical branching questionnaire to see which format can obtain a history more effectively. Both questionnaires start with a few broad questions relevant to presenting the patient's region of illness. The decision-driven data acquisition questionnaire then selects questions to ask the patient depending on the likelihood of the patient having a specific disease state. The hierarchical branching questionnaire uses a branching pattern whereby positive responses lead to more detailed questions on that topic. Both methods were evaluated by examining the number of questions each would ask, amount of time used for each history, and the accuracy of the history. The number of questions asked by a history and the amount of time a history takes have been shown to be of significance in the patient acceptance of the history (10, 11). The evaluation of the accuracy of the history is a problem. Grossman states that evaluation of the quality of historical data is difficult since there are no absolute standards of completeness or accuracy (12). Studies have shown there is great variability between the symptoms included in histories collected by different physicians on the same patient.(1) The true symptom profiles of the patient are rarely known making it difficult to form an opinion on their validity. Studies have shown there is less variability between diagnosis between physicians than in the histories they collect.(1)

Background of Computerized Histories

This is a brief review of previous work conducted to collect a general medical history. A review of automated medical records needs to begin with the development of the self-administered questionnaire. Only a few scientists have developed programs to conduct a general medical history. Because of the broad expanse of information needed in a general questionnaire, most of the programs deal with a given disease, or a group of diseases. When some reseachers realized that a branching questionnaire would not allow them practical means to collect enough information, they started to explore medical artificial intelligence (MIA) methods. They developed systems designed to exhibit the characteristics we associate with intelligence in human behavior (e.g., understanding language, learning, reasoning, problem solving) to select the questions to be asked.

Cornell Medical Index (CMI) developed by Brodman et al. in the early 1940s was the one of the first questionnaires to come into general use (13).This paper-and-pencil questionnaire contains four pages with 195 questions concerning family medical history, past illness, present symptoms, and patient behavior. The questionnaire contains fixed question format to which the patient responses YES/NO, and an additional sheet for patient to write present illness.

Since the 1950s, Collen at the Kaiser-Permanente Medical Center has been using a multiphasic health testing questionnaire (14). The questionnaire consists of 204 prepunched data processing cards with an individual question printed on each card, and a pencil-and paper questionnaire. The patients sort the cards into YES/NO sections of a divided tray. The cards in the YES section are read into a computer and a report is generated. There is no variation in the questions the patients receive.

Slack and his co-workers at the University of Wisconsin pioneered the online computer based questionnaire (with a questionnaire for allergies) in the mid-1960s (3). They used a Cathode Ray Tube (CRT) and a keyboard for a self-administered history. Their questionnaire used branching techniques that allowed flexibility in questioning. A YES

response is followed up with more detailed questions. The questionnaire contained more than 500 questions, but the maximum number asked to any patient would be 320. The mean time of completion of the questionnaire was 15 to 20 minutes. The results were summarized and printed out for the physician.

Mayne's group at the Mayo clinic first developed a computerized branching questionnaire, the Automated Medical History (AMH), where patients used a light pen to answer questions (15). The questionnaire contained two levels of questions, first broad question followed by more specific branch questions. Because of the expense of the system it has been replaced by the development of the Patient Inventory Questionnaire (PIQ) (4, 16). The PIQ is a three level mark-sense, paper-and-pencil computer generated questionnaire. The first level (PIQ-1) has two versions, male or female, and contains broad screening questions for a review of systems. The second level (PIQ-2) is generated from the response of PIQ-1. It follows-up on the frequency, location, severity of the complaints in PIQ-1. PIQ-3 follows-up on PIQ-2 isolating clinical symptoms, signs and therapeutic experiences.

Grossman and associates have explored on-line history taking through the use of several terminals connected in the Massachetts General Hospital (12). In the use of their system, Automated Medical History (AMH), paramedical personnel begin the questionnaire by entering basic demographic information, followed by the patient using the terminal to answer a branching questionnaire. The questionnaire takes a mean time of 45 minutes and asks a mean of 157 questions.

At the Lahey Clinic Foundation, Rockart and associates have developed the Automated Medical History System (AMHS)(17). The AMHS questionnaire is designed to be mailed to patients in advance of their clinic visit. The forms are then processed in batch and reports printed out before the patient visit. The branching questionnaire consists of a 25 page booklet with 160 questions (with 619 responses possible) and space for the patient to describe his chief complaint. The patient responses are read with an optical scanner and a

computerized report form is generated to go with the handwritten chief complaint section.

The Automated Patient History Acquisition System (APHAS) was developed by Simmons and associates at the University of Missouri (18). It is an audiovisual assisted automated system. It contains computer-controlled projected illustrations and tape-recorded messages. The branching history with 806 possible questions, starts with 85 questions, then selects the body system associated with the patient symptoms and asks a series of disease related questions in that area.

Warner et al. developed a computerized history, the Health Evaluation through Logical Processing (HELP) system, at LDS Hospital in the late 1960s (19). Their approach was to limit the number of questions asked to obtain a history of present illness, by estimating the probability of the disease state and using this information to select the next set of questions.A matrix of estimated probabilities (matrix of diagnosis versus questions) was developed to use in Bayes equation.The program had the possibility of asking 320 questions involved in 134 disease states.

Pauker, Gorry and associates developed PIP (Present Illness Program) that uses unstructured problem-solving techniques to take the history of the present illness of the patient with edema (20). It was designed for use by physicians and does not interact with with patients. The program works with a large set of possible findings (that trigger or activate a hypothesis) and a separate set of hypotheses (that contain a set of prototypical findings that can either support or refute the hypothesis). Findings reported by the user are matched against these prototypical findings and, if a match occurs, PIP's belief in the hypothesis is reevaluated. Once the reevaluation of all the hypothseses affected by the last finding is done, PIP selects the appropriate question to ask the user by selecting the highest scoring active hypothesis. The program cycles (that is characterizes findings, seeks advice on how to proceed, generates hypotheses, tests hypotheses and selects questions) until all active hypothesis are explored.

MYCIN was developed at Stanford by Shortliffe and Buchanan to advise physians in the

apporiate treatment of infections (21). MYCIN's knowledge base contains information about infectious disease (about 500 rules) written in the form of IF-THEN statements. Its data base contains information about specific patients written in the form of "attribute-object-value" triplets. An inference engine then uses the information (or lack of information) in the data base to operate on the knowledge base to draw conclusions or ask questions. It uses a backward chaining deduction scheme in which all applicable rules are tried; if a condition in the IF part of a rule is decidable from the data base, that is done; if the condition can be aserted by the THEN part of some other rules, they are applied; otherwise MYCIN asks the user a question. Typical users are physicians seeking a consultation.

INTERNIST is a computer based diagnostic consultant for internal medicine (22). It has been developed by Polpe and Mayers at the University of Pittsburg and contains a knowledge base of over 600 disease profiles and recognizes over 4000 individual manifestations. The behavior of INTERNIST results primarily from the appliction of two heuristic principles; the formation of problem areas though a partitioning algorithm and the conclusion of diagnosis within problem areas, using strategies such as diagnosis by exclusion. In INTERNIST the data base associates with every possible diagnosis a set of manifestations. The disease profiles are then inverted by a computer program to produce, for each manifestation, a list of all diagnoses for these disease profiles. The user enters a set of initial findings (manifestations). Each manifestation generates a complete differential diagnosis (set of disease hypothesis) from the inverted disease profiles in the knowledge base. Each hypothesis is given a score and the hypotheses are sorted in descending order. Next the diagnostic logic (the partitioner) delineates a set of competitors (When two disease states taken together explain no more observed manifestations than does either one taken alone they are considered competitors) from which the current problem area is constructed. If more than one hypothesis is in the problem area, additional questions are asked to exclude some hypothesis or support a single most likely hypothesis. The program continues to

cycle (questioning, scoring hypotheses, selecting problem areas) until there is only one disease in the problem area. This disease is considered the patient diagnosis. If a single diagnostic conclusion cannot be reached a diagnostic list will be given.

Thesis Objectives

The specific objectives of this thesis are:

1. To design and implement computerized questionnaires to be used for obtaining patient history data from patients entering the hospital for elective surgery, and to test their effectiveness.

2. To evaluate if there is a significant difference between the Decision-Driven Data Acquisition and the Hierarchical Branching Questionnaire. To evaluate both methods by examining the number of questions each would ask, amount of time used for each history, and the accuracy of the history.

3. To evaluate first, the patient's acceptance and comfort in using the computerized history, and second the patient's evaluation of the patient questionnaire (i.e., if the questionnaire asked valid questions and a thorough history was taken).

4. To develop a physician report form that would allow the physician to effectively examine the patient history information stored in the patient's file that is useful in decision making.

5. To collect and evaluate the physician's comments on the validity and completeness of the computerized history.

CHAPTER 2

METHODS

The HELP System

The goal of this project was to capture a patient history and store it in a computer system to help manage the patient care. This process took place within the HELP (Health Evaluation through Logical Processing) system. The HELP system has been developed over the past 20 years at LDS Hospital to support the financial, administrative, and medical needs of a 550 bed tertiary care teaching hospital (23, 24). It has been developed to provide not only data management for a HIS (Hospital Information System), but also to provide computerized decision support in clinical care. An overview of the system is shown in Figure 1.

At the core of the HELP system is an online clinical data base containing patient specific information. The data are acquired through applications written using branching questionnaire, decision-driven data acquisition processes (DDA), direct input from other computers. These applications include: ADT (admit, discharge and transfer), order entry, charge capture, medical records, automated monitoring, nurse charting, nursing care plans, radiology, surgery scheduling and management, laboratory and pathology integration, pharmacy, laboratory alerting, blood gas analysis, pulmonary function laboratory, respiratory care, cardiology /ECG, obstetrics and patient history.

The patient information can then be utilized by the knowledge base. The knowledge base is represented in the form of independent frames known as HELP sectors. The frames support decision applications available in the monitoring of medication contraindications,

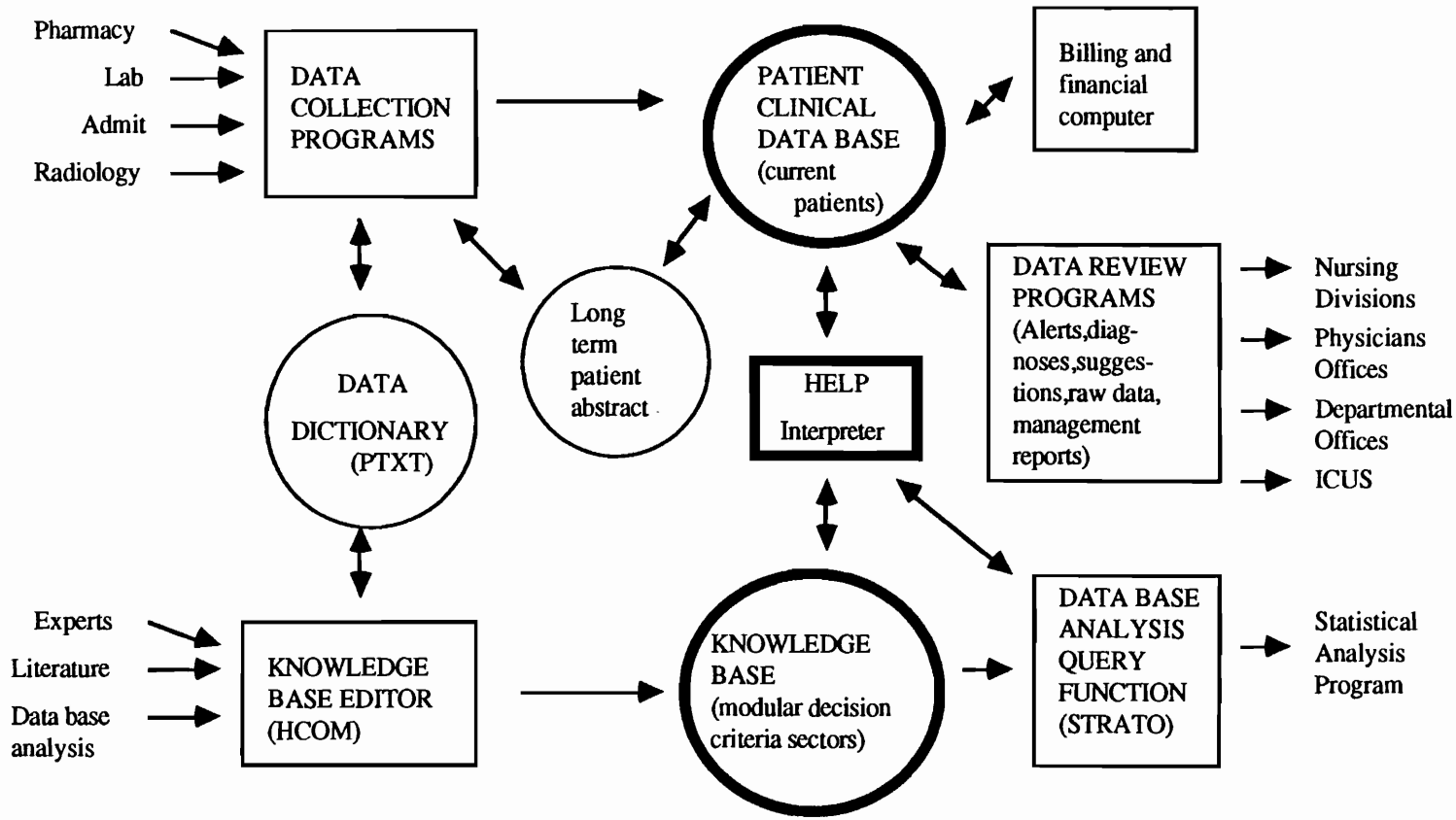


FIGURE 1. The HELP System

blood gas and ECG interpretations, infectious disease and microbiology alerting, disease diagnosis from patient histories, automated determinations of key X-ray findings, heart catheterization interpretations, hemodynamic evaluation, therapeutic protocols, decision analysis support, etc.

PTXT: The Data Dictionary

To store the patient data in an easily referenced and retrievable form the data are coded using a data dictionary. The data dictionary, PTXT (pointer to text), is used to store information in a uniquely identifiable form. When a medical term is defined in the system a relation with several fields is built for each entity or medical term defined. The first field of each relation is the hierarchical code, which acts as a unique key for the entity. The medical terminology is stored in the second field followed by fields containing miscellaneous information such as charges and ending with a group of fields containing key words (synonyms) for each term.

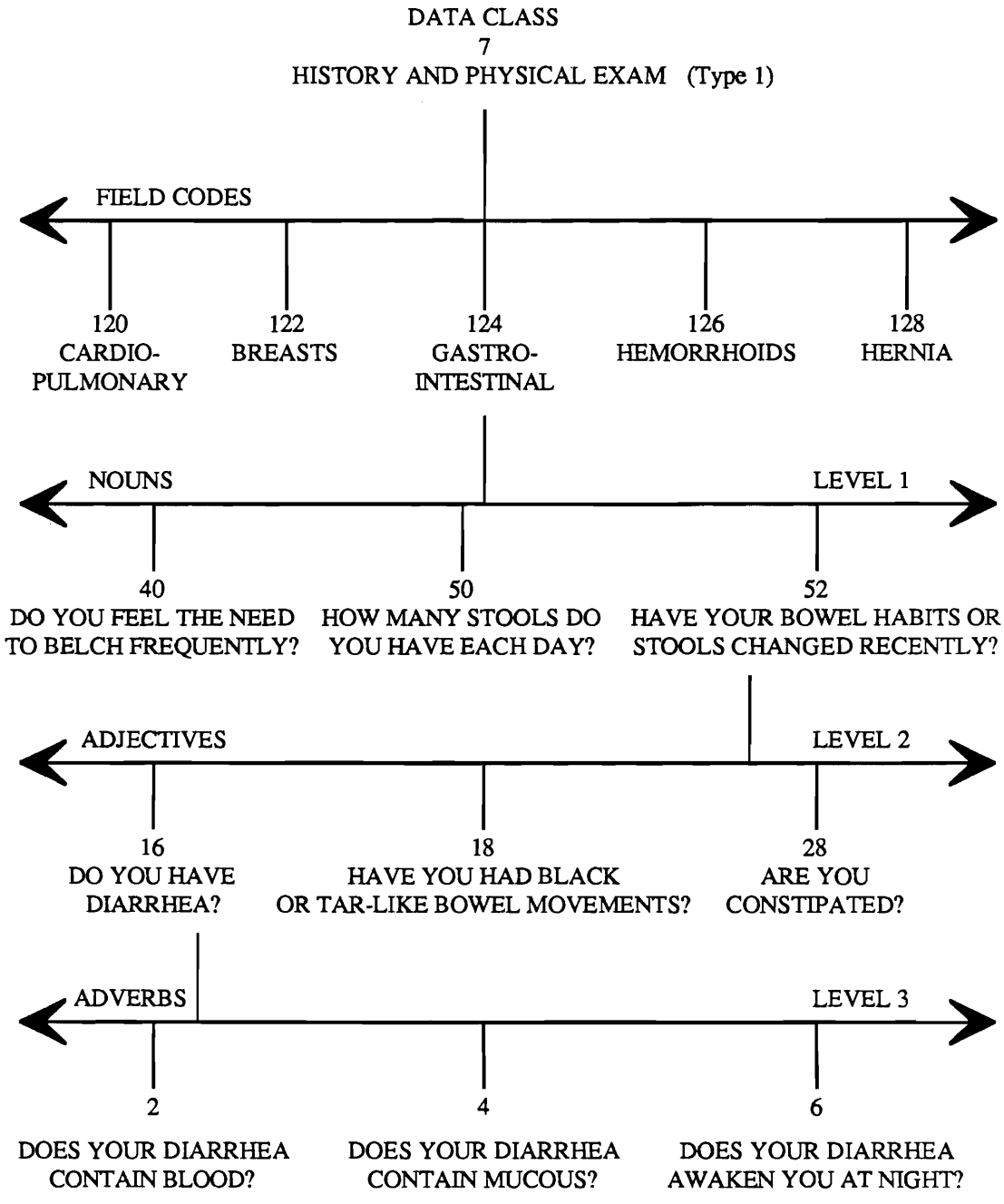
The hierarchical code or unique key for each term is derived from the position of the defined term in a hierarchical structure representative of the terminology found in medicine. The names of the levels in the hierarchical structure are from top to bottom: data class, data type, field code, level, noun, adjective, adverb. Data classes are used to define subspecialty areas in medicine, e.g., pharmacy (drugs), surgical procedures, radiology procedures, chemistry laboratory, microbiology, history, and physical examination. Data types are used to identify the structure in which the data string is constructed. They indicate either that further hierarchy will be coded or that lower levels of information will be stored in a relational structure. The contents of the type one data string are self-defining with certain reserved symbols telling what kind of information is to follow. This is in comparison with the type zero data, where the structure is a defined relation and the location of the data defines its meaning in a fixed-length string. Field codes subdivide the data classes into smaller groups.

In history and physical examination the field codes define areas like constitutional, cardiopulmonary, gastrointestinal, gynecological, neurological, medications, allergies, past medical history, social history, and miscellaneous questions. The field code is followed by a coded number, one to three, that indicates the level of the text with a one for a noun level question, two for an adjective, and three for a adverb level. The next levels of classification or subdivision are nouns, adjectives, and adverbs. An example their usage can be shown in the decoding of 7 1 124 3 52 16 2 (Figure 2). Seven represents the data class defined as as history and physical examination, 1 identifies it as type one data, 124 gives the field code as gastrointestinal, the 3 defines the code as representing an adverb, 52 is the noun level branch that contains the question 'HAVE YOUR BOWEL OR STOOLS CHANGED RECENTLY?', 16 is the adjective level question 'DO YOU HAVE DIARRHEA?' and the code ends with a 2 in the adverb level where the text contains the question 'DOES YOUR DIARRHEA CONTAIN BLOOD?'.

To find terms previously defined in PTXT one can enter a keyword or synonym. For example, if the key word 'DIARRHEA' was entered, the dictionary would be searched for all entries of this keyword, then it would list the 39 entries in which diarrhea is already defined in the system and the user can select the appropriate item. In doing this the user need not know the exact codes for the terms being used. In contrast, the first time user for different terminology not defined in the PTXT must define the hierarchy for the domain they are using. They must be aware of how to enter text, how PTXT is structured, and where to insert the new text.

Additions and Revisions of the PTXT

The structure and syntax of the PTXT are very important to this project. First the syntax is important, because if the computer history asks a question that is not clear to the patient or user, the computer is not programmed to restate the question or give further explanations. Second, the structure of the PTXT is used in structuring both questionnaires,



The PTXT code for the history question
'DOES YOUR DIARRHEA CONTAIN BLOOD' would be:

Data Class	Type	Field Code	Level	Noun	Adjective	Adverb
7	1	124	3	52	16	2

Figure 2. Hierarchical data base structure.

especially structuring the hierarchical questionnaire. The syntax of the physicians report is also very important because, if the physician does not find the report easy to use, he will not use the computerized history with his patients. The last factor to consider involves the commitment to using PTXT already written in the system without adding a whole new set for this project.

The original PTXT for patient history was entered over the years by a number of Medical and Biophysics students. Most of it originated with a screening history developed in the early 1970s for obtaining a computerized history on admission to the hospital (4). The PTXT for the original project was entered as type zero data to be used in a multiple choice questionnaire. For this project the type zero data were rewritten as type one data. In the transfer process, and in using the questions in a YES/NO context, some of the questions lost their original intent. If patients have a chance to choose one of four statements that suits situation the best, they may select: 'I HAVE BEEN MORE SHORT OF BREATH RECENTLY.' In the type one data this was translated to the question: 'HAVE YOU BEEN MORE SHORT OF BREATH RECENTLY?' This questions uses comparative (subjective) terminology, such as, 'recently' and 'more', which makes it hard for the patient to interpret the question in a YES/NO answer. The patient does not know if 'recently' means a month, week or day. Does 'more short of breath' mean being short of breath after going up the stairs, or just sitting? It is hard to quantitate what is 'more'.

Another problem was isolated after giving the history. Some text was phrased in a way that it received the same answer from all patients. An example of this was 'DO YOU FEEL WEAK AND GET TIRED EASILY?' Almost all patients coming into the hospital feel tired. The tiredness is due not only to illness but also the stress of entering the hospital. This was changed to 'HAVE YOU RECENTLY BEEN TOO TIRED TO GET YOUR DAILY WORK DONE?'

This project needed the PTXT to be very strictly structured in each field code. If patients answer NO to a noun level question, they will not see the adjective level questions or adverb

level questions under the noun level question. Therefore the adjective level questions have to directly follow the line of questioning of the noun level question and the adverb level must follow the adjective level question. However, if one increases the number of noun questions, the total number of questions the patient has to answer increases dramatically. The goal is, therefore, to have a fewer number of noun questions that are very broad questions, that are followed-up with more specific adjective and adverb questions. By having fewer noun level question, followed by more adjective or adverb questions, the questionnaires are streamlined.

In the existing PTXT, it was found that field codes dealing with present illness contained many questions dealing with the patient's past medical history. For example, the cardiopulmonary field code contained the text 'HAVE YOU EVER HAD ASTHMA'. This caused an overlap in PTXT text of the present and past medical history field codes. It also caused confusion in trying to tell if the question was dealing with past or current conditions. The text was either changed from past to present tense or the text was moved to the past medical history field code.

While reviewing the PTXT hierarchical structure, it was determined that past surgical history should be contained in a separate field code rather than in past medical history. A past surgical history field code was added and surgical questions moved to the new field code.

Physicians prefer to see data in report forms as statements in medical terminology. The PTXT used in the patient histories consists of questions phased in a manner that is easy for the patient to understand. To please both groups, the patient PTXT was mirrored with a separate physician PTXT. The data class 57, Physician History and Physical Exam Review, gives analogous messages to the Patient History and Physical Exam, data class 7 (Figure 3). Patients are asked the questions in data class 7 (i.e., 'DOES MILK SEEM TO MAKE YOUR SYMPTOMS WORSE?') and the program that prints out the report form, prints out the message in data class 57(i.e., MILK INTOLERANCE).

dc fc noun adj adv History questions as they are viewed by the patient:

dc	fc	noun	adj	adv	
7	124	52	0	0	HAVE YOUR BOWEL HABITS OR STOOLS CHANGED RECENTLY?
7	124	52	16	0	DO YOU HAVE DIARRHEA?
7	124	52	16	2	DOES YOUR DIARRHEA CONTAIN BLOOD?
7	124	52	16	4	DOES YOUR DIARRHEA CONTAIN MUCOUS?
7	124	52	16	6	DOES YOUR DIARRHEA AWAKEN YOU AT NIGHT?
7	124	52	18	0	HAVE YOU HAD BLACK OR TAR-LIKE BOWEL MOVEMENTS?
7	124	52	20	0	ARE YOU BOWEL MOVEMENTS PALE OR CLAY COLORED?
7	124	52	26	0	HAS THERE BEEN BLOOD IN YOUR STOOL LATELY?
7	124	52	28	0	ARE YOU CONSTIPATED?
7	124	52	32	0	DOES MILK SEEM TO MAKE YOUR SYMPTOMS WORSE?
7	124	52	36	0	DO YOU HAVE DIARRHEA ALTERNATING WITH CONSTIPATION
7	124	52	38	0	HAVE YOU BEEN PASSING AN UNUSUAL AMOUNT OF GAS?

dc fc noun adj adv Analogous messages as viewed on the physician report form:

dc	fc	noun	adj	adv	
57	124	52	0	0	A CHANGE IN STOOLS OR BOWEL HABITS
57	124	52	16	0	DIARRHEA
57	124	52	16	2	BLOODY DIARRHEA
57	124	52	16	4	DIARRHEA CONTAINING MUCUS
57	124	52	16	6	DIARRHEA, AWAKENS PT DURING NIGHT
57	124	52	20	0	CLAY COLORED STOOL
57	124	52	26	0	BLOODY STOOL
57	124	52	28	0	CONSTIPATION
57	124	52	32	0	TENESMUS
57	124	52	34	0	SYMPTOMS INCREASED BY MILK INGESTION
57	124	52	36	0	DIARRHEA/CONSTIPATION ALTERNATING
57	124	52	38	0	INCREASED FLATULANCE

dc = data class; fc = field code; adj. = adjective; adv. = adverb

FIGURE 3 . Gastoenterology History Text Comparison of Patient and Physician Text

Structuring the History

A goal of this project was not only to enter a history into the computer system, but to compare two methods used to structure the history. One method was to have a hierarchical branching questionnaire with a fixed branching structure. The other method was a decision-driven data acquisition approach that considered past answers before deciding which questions to ask.

PTXT was added to structure both of the questionnaires. The new PTXT was used in the first three screens in both histories. The rest of the questions were then keyed off these three screens. The first screen gave a noun level question: 'THIS IS A COMPUTER PROGRAM DESIGNED TO ASK YOU ABOUT THE PROBLEMS THAT BRING YOU TO THE HOSPITAL. THE RESULTS ARE GIVEN TO YOUR PHYSICIAN. ARE YOU READY TO ANSWER SOME QUESTIONS ABOUT YOUR ILLNESS?' Then in order for the questionnaires to isolate the patient's complaint to a specific system, the noun question is followed by adjective level major system questions. The next two screens contain nine adjective level questions structured under this noun (Figure 4). They are lead questions that try to find out in what areas the patient is having problems. These questions are then used to direct the rest of the questioning process.

Knowledge Base

The knowledge in the system was to be based on 134 disease states selected with the assistance of the LDS Hospital chief of surgery. These were disease states that could possibly cause problems to patients undergoing surgery. The set of 134 diseases contained a PTXT file too large for the allocated buffer, so a subset of 72 disease states was selected (Figure 5). In the end, the study was based on finding the symptoms involved in 72 disease states and two additional frames looking for allergies and a past surgical history. By developing a questionnaire asking questions used to diagnose the disease states, a patient history evolves that can be used to deduce possible complicating factors for surgery.

ARE YOU HAVING A PROBLEM WITH YOUR HEAD OR NECK?

ARE YOU HAVING PROBLEMS WITH YOUR EYES, EARS, NOSE, OR THROAT?

ARE YOU HAVING PROBLEMS WITH YOUR LUNGS, HEART, OR CHEST?

ARE YOU HAVING PROBLEMS WITH YOUR ABDOMEN OR STOMACH?

ARE YOU HAVING A PROBLEM WITH YOUR URINATION OR YOUR KIDNEY?

ARE YOU HAVING A PROBLEM WITH YOUR JOINTS, BONES, OR BACK?

ARE YOU HAVING PROBLEMS WITH YOUR UTERUS, OVARIES, OR REPRODUCTIVE ORGANS?

(ASKED ONLY IF FEMALE)

HAVE YOU HAD ANY PROBLEMS WITH EITHER BREAST?

(ASKED ONLY IF FEMALE)

ARE YOU HAVING A PROBLEM WITH YOUR GENITAL ORGANS?

(ASKED ONLY IF MALE)

IS YOUR MAIN PROBLEM WITH FATIGUE, WEAKNESS, OR GENERAL ACHING?

HAVE YOU BEEN FEELING UNUSUALLY ANXIOUS OR DEPRESSED LATELY?

ARE YOU EXPECTING SURGERY DURING THIS HOSPITALIZATION?

FIGURE 4. Key Questions

PULMONARY

PNEUMONIA
PULMONARY EDEMA/CHF
REACTIVE AIRWAY DISEASE (ASTHMA)
PULMONARY NEOPLASM
ACUTE BACTERIAL BRONCHITIS
RISK FACTORS FOR LUNG ABSCESS
MYCOPLASMA PNEUMONIA
PNEUMOCOCCAL PNEUMONIA
ASBESTOSIS
COAL WORKER'S PNEUMOCONIOSIS
METASTATIC NEOPLASM
DIFFUSE IDIOPATHIC PULMONARY FIBROSIS
CHRONIC BRONCHITIS
EMPHYSEMA
BRONCHIECIASIS
PULMONARY TUBERCULOSIS
INFLUENZA
LUNG ABSCESS(CONTINUED)
LEGIONNAIRES DISEASE
SILICOSIS
ASPERATION PNEUMONIA
PULMONARY HYPERTENSION
NON-HODGKIN'S LYMPHOMA
RHEUMATOID LUNG DISEASE

CARDIOLOGY

MYOCARDIAL INFARCT
ACUTE PERICARDITIS
ANGINA PECTORIS

GASTROENTEROLOGY

DUODENAL ULCER
DIVERTICULITIS
ULCERATIVE COLITIS
IRRITABLE BOWEL
CARCINOMA OF THE COLON
PANCREATITIS
INTESTINAL OBSTRUCTION
HEPATITIS
ACUTE CHOLESCYSTITIS
APPENDICITIS
CROHN'S DISEASE
CARCINOMA OF THE STOMACH
GASTROENTERITIS
ESOPHAGEAL REFLUX
CHOLEDOCHOLITHIASIS

NEPHROLOGY

RENAL INSUFFICIENCY
RENAL STONE
PYELONEPHRITIS

ENDOCRINOLOGY

DIABETES MELLITUS
HYPERTHYROIDISM
HYPOTHYROIDISM
ADDISON'S DISEASE
HYPERPARATHYROIDISM
CUSHING'S SYNDROME
PHEOCHROMOCYTOMA

RHEUMATOLOGY

TEMPORAL ARTHRITIS
SYSTEMIC LUPUS ERYTHEMATOSIS
RHEUMATOID ARTHRITIS

NEUROLOGY

TRANSIENT ISCHEMIC ATTACKS
CHRONIC GLAUCOMA
EPILEPSY

HEMATOLOGY

ANEMIA
BLEEDING DIATHESIS
ACUTE HEMOLYTIC ANEMIA
LEUKEMIA

OBSTETRICS, GYNECOLOGY, AND UROLOGY

MENO-METRORRHAGIA
CYSTITIS
DISEASE
ECTOPIC PREGNANCY
PROSTATIC HYPERTROPHY
PREGNANCY
PELVIC INFLAMMATORY
BREAST TUMOR

MISCELLANEOUS

SINUSITIS
ALLERGIES
REGION OF ILLNESS
PHARYNGITIS
PAST SURGICAL HISTORY

FIGURE 5. Disease States Selected for Knowledge Frames

The knowledge base consists of a series of independent diagnostic sections called HELP frames. Each of the disease states has a corresponding HELP frame. A HELP frame is a medical decision algorithm written using search statements, arithmetic relations, "if... then..." logic and probabilistic logic (based on Bayes' equation (25, 26)). Figure 6 is an example of a HELP frame for the diagnosis of appendicitis. It has a typical structure of most frames used in this study. Each frame has the following components: 1) A title or text string that contains a message displayed when the frame criteria are satisfied. The spaces in the message with the equal signs will be filled in with the likelihood of the patient having the disease. The likelihood is generated by the frame and stored in the slot labled FINAL EVALUATION. 2) A list of destinations to which the text is to be sent . 3) The sector logic which usually begins with an a priori probability for the diagnosis of the disease in question followed by a series of search statements.The search statements search for a list of data (answers to specific questions or facts such as age) from the patient data base to be used in making a medical decision. 4) A list of arithmetic, logical, or probabilistic logic which define the decision criteria. This section ends with two statements. The first contains the authors control logic for presenting a question and the second is the ASK function, which indicates the questions that should be asked, if their answer is unknown, to the patient.

The search statement directs searches in the patient files for data items (PTXT) asked for within the frames. The search statement can have time constraints to limit searches to specific time frames. Arithmetic items may use any kind of mathematical functions needed to represent the logical model of a decision. The bayesian logic uses the probability of the disease state being true before the consideration of the item (the a priori probability), its sensitivity, and the items specificity to calculate the posterior probability.

A HELP frame contains all the information one needs to diagnose a specific disease, the questions to be asked, the logic, and the probabilities. One may specify which search items

```
BLOCK #7.143  GASTROENTEROLOGY SECTORS[ANY SECTOR]
SECTOR 4  =.== APPENDICITIS (HISTORY) ====.===

   OWNER: HELP.PETER  SECURITY: AAAA  PRIORITY: 0
   ALWAYS SEND  DESTINATION LIST: TO CALLING PROGRAM,
      TO INFA FOR DEBUGGING, TO PATIENT RECORD

   FINAL EVALUATIONS:
   A VAL: P
   B VAL: P/A

   SECTOR LOGIC:
   A ARITH:  0.013
   B SEARCH: ^ (A) [FC] GASTROINTESTINAL, [N] HAVE YOU HAD RECENT PAIN
         OR TENDERNESS IN YOUR ABDOMEN?
      FROM:  0,  IF ex: VAL SUBITEM A GE 5
   C SEARCH: # (A) [FC] GASTROINTESTINAL, [N] HAVE YOU HAD RECENT PAIN
            OR TENDERNESS IN YOUR ABDOMEN?, [ADJ] DOES YOUR ABDOMEN
            HURT WHEN YOU MOVE AROUND OR COUGH?
      FROM:  0,  IF ex: A
   D SEARCH: # (A) [FC] GASTROINTESTINAL, [N] HAVE YOU HAD RECENT PAIN
            OR TENDERNESS IN YOUR ABDOMEN?, [ADJ] DOES YOUR ABDOMINAL
            PAIN LAST LONGER THAN 30 MINUTES?
      FROM:  0,  IF ex: A
   E SEARCH: # (A) [FC] GASTROINTESTINAL, [N] HAVE YOU HAD RECENT PAIN
            OR TENDERNESS IN YOUR ABDOMEN?, [ADJ] IS THE PAIN THE
            WORST IN YOU LOWER RIGHT ABDOMEN?
      FROM:  0,  IF ex: A
   F SEARCH:  (A) [FC] GASTROINTESTINAL, [N] ARE YOU CONSTIPATED?
      FROM:  0,  IF ex: A
   G SEARCH: # (A) [FC] GASTROINTESTINAL, [N] HAVE YOU HAD RECENT PAIN
            OR TENDERNESS IN YOUR ABDOMEN?, [ADJ] IS YOUR ABDOMINAL
            PAIN SHARP OR CRAMPING?
      FROM:  0,  IF ex: A
   H SEARCH: # (A) [FC] GASTROINTESTINAL, [N] HAVE YOU HAD RECENT PAIN
            OR TENDERNESS IN YOUR ABDOMEN?, [ADJ] DOES BENDING MAKE
            YOUR ABDOMINAL PAIN WORSE?
      FROM:  0,  IF ex: A
   I SEARCH: # (A) [FC] GASTROINTESTINAL, [N] HAVE YOU RECENTLY BEEN
            NAUSEATED OR BEEN VOMITING?, [ADJ] HAVE YOU BEEN
            VOMITING?
      FROM:  0,  IF ex: A
   J PROB: A,  IF ex: C,  USE val: C,  MIN: (1, 5)  TRUE:   (0.12, 0.88),  FALSE: (0.93, 0.07)
   K PROB: J,  IF ex: D,  USE val: D,  MIN: (1, 5)  TRUE:   (0.27, 0.73),  FALSE: (0.85, 0.15)
   L PROB: K,  IF ex: E,  USE val: E,  MIN: (1, 5)  TRUE:   (0.22, 0.78),  FALSE: (0.83, 0.17)
   M PROB: L,  IF ex: F,  USE val: F,  MIN: (1, 5)  TRUE:   (0.5, 0.5),    FALSE: (0.82, 0.18)
   N PROB: M,  IF ex: G,  USE val: G,  MIN: (1, 5)  TRUE:   (0.33, 0.67),  FALSE: (0.86, 0.14)
   O PROB: N,  IF ex: H,  USE val: H,  MIN: (1, 5)  TRUE:   (0.75, 0.25),  FALSE: (0.86, 0.14)
   P PROB: O,  IF ex: I,   USE val: I,  MIN: (1, 5)  TRUE:   (0.85, 0.15),  FALSE: (0.98, 0.02)
   Q ARITH:  IF P LT A THEN GOTO FE
   R EXIST:  ASK((PATIENT QUESTIONS)C, D, E, F, G, H, I)
```

FIGURE 6. HELP Frame for Appendicitis

in a sector are to be used to automatically evoke the sector. The ^ items in this sector drive the sector. In this example, of appendicitis, if a patient answered YES to the question, 'HAVE YOU HAD RECENT PAIN OR TENDERNESS IN YOUR ABDOMEN?, the sector would be evaluated. If the probability of having the disease is higher then a set level the rest of the questions will be asked. A search item may be flagged as 'hierarchical' by placing a # sign in front of the item. If the item is marked with a # sign, it allows the sector to infer the answer of an adjective or adverb question is NO if, its 'parent' in the PTXT hierarchy (i.e., the noun level) has a NO answer stored.

Decision-driven Data Acquisition

As stated, two approaches were used to collect patient histories in the project, a branching questionnaire and a special purpose decision-driven data acquisition (DDA) program (27). The goal of the DDA program was to use the knowledge base consisting of the disease frames to direct the questioning. It was intended to select the least number of questions possible while collecting a complete and accurate history. The decision-driven system directs the program to ask questions related to the most likely disease states. With the new information, the DDA program evaluates the probability of each disease state and selects new questions to be asked. It operates in this cyclic fashion until it has obtained answers bearing on all probable disease states, then the questioning process terminates.

The process begins with one frame containing the nine generalized key questions as stated above. An affirmative answer to these questions will trigger any of a group of review-of-system frames. The review-of-system frames contain key questions related to diseases in a specific system. For example the gastroenterology review-of-system frame contains five key questions that drive the 15 gastroenterology disease frames (Figure 7). In each of the individual disease frames one or more of the data items is deemed to be an important parameter of the disease state (marked with a ^) and is used to drive or trigger the frame. An affirmative answer to a question in the review-of-system frame applies to one of

```
BLOCK #7.143   GASTROENTEROLOGY SECTORS[ANY SECTOR]
SECTOR 100   GI ROS

   OWNER: HELP.PETER   SECURITY: AAAA   PRIORITY: 0
   ALWAYS SEND   DESTINATION LIST: TO PATIENT RECORD


   FINAL EVALUATIONS:
   A  VAL: H

   SECTOR LOGIC:
   A  SEARCH: & (A) [FC] MISCELLANEOUS QUESTIONS, [N] THIS IS A COMPUTER
            PROGRAM DESIGNED TO ASK YOU ABOUT THE PROBLEMS THAT BRING
            YOU TO THE HOSPITAL.  THE RESULTS ARE GIVEN TO YOUR
            PHYSICIAN.  ARE YOU READY TO ANSWER SOME QUESTIONS ABOUT
            YOUR ILLNESS?, [ADJ] ARE YOU HAVING PROBLEMS WITH YOUR
            ABDOMEN OR STOMACH?
     FROM:    0,  IF ex: VAL SUBITEM A GE 5
   B  SEARCH: & (A) [FC] GASTROINTESTINAL, [N] HAVE YOU HAD RECENT PAIN
           OR TENDERNESS IN YOUR ABDOMEN?, [ADJ] IS THE PAIN THE
            WORST IN YOUR UPPER MIDDLE ABDOMEN?, (B) [ADJ] IS THE
            PAIN THE WORST IN YOUR RIGHT UPPER ABDOMEN?, (C) [ADJ] IS
            THE PAIN THE WORST IN YOUR LEFT UPPER ABDOMEN?, (D) [ADJ]
            IS THE PAIN THE WORST IN YOUR LOWER MIDDLE ABDOMEN?, (E)
            [ADJ] IS THE PAIN THE WORST IN YOU LOWER RIGHT ABDOMEN?,
            (F) [ADJ] IS THE PAIN THE WORST IN YOUR LOWER LEFT
            ABDOMEN?
     FROM:    0,  IF ex: A OR B OR C OR D OR E OR F
   C  SEARCH: & (A) [FC] GASTROINTESTINAL, [N] HAVE YOUR BOWEL HABITS OR
            STOOLS CHANGED RECENTLY?, [ADJ] DO YOU HAVE DIARRHEA?
     FROM:    0,  IF ex: A
   D  SEARCH: ^ (A) [FC] GASTROINTESTINAL, [N] HAVE YOU RECENTLY BEEN
            NAUSEATED OR BEEN VOMITING?
     FROM:    0,  IF ex: A
   E  SEARCH: & (A) [FC] GASTROINTESTINAL, [N] HAVE YOUR BOWEL HABITS OR
            STOOLS CHANGED RECENTLY?, [ADJ] HAVE YOU HAD BLACK OR
            TAR-LIKE BOWEL MOVEMENTS?
     FROM:    0,  IF ex: A
   F  SEARCH: & (A) [FC] GASTROINTESTINAL, [N] HAVE YOUR BOWEL HABITS OR
            STOOLS CHANGED RECENTLY?, [ADJ] HAS THERE BEEN BLOOD IN
            YOUR STOOL LATELY?
     FROM:    0,  IF ex: A
   G  EXIST:   ASK((PATIENT QUESTIONS)B, C, D, E, F)
   H  ARITH:   1
   I  EXIST:   IF B AND C AND D AND E AND F THEN VAL ITEM H = 0
```

FIGURE 7. HELP Frame for Gastroenterology Review-of-System

the key questions in one or more individual disease frames causing the frame or frames to be evaluated. If the probability of having the disease state is above the a priori then the rest of the questions in the frame will be asked.

The screening program utilizes 85 frames . The 85 frames consist of the 74 disease frames, 10 review-of-system frames, and the region of illness frame. It is driven by a region of illness frame that contains 12 questions that every patient has to answer (Figure 8). A positive answer in the region of illness frame will trigger one or more of the 10 review-of-system frames. Every patient is asked a minimum of three allergy questions at the end of the session. Utilizing this structure the patient could be asked a minimum of 16 questions and a maximum of 359 questions.

Hierarchical Branching Questionnaire

The second approach used in collecting a patient history was to use a branching questionnaire. In developing the questionnaire it was structured to ask the least number of questions possible without missing any relevant data. It was also necessary to have an answer inserted in response to each question used in any frame. The HELP system tool QSTN (23) was used to write the questionnaire. The branching questionnaire section was structured hierarchically using the built-in hierarchical structure of PTXT and key questions.

The branching questionnaire program presents questions to the patient, prompts the patient to answer the question, stores the answer, and contains follow-up logic to select the next question until termination of the questionnaire. The questionnaire developed in this project used Data Entry and No User Entry questions in a branching questionnaire. In the Data Entry questions the screen consisted of the Text of 5 to 7 PTXT questions, giving the patient the option of answering each question with a YES or a NO. After the questions were answered the questionnaire branched according to the follow-up logic. If the patient answers YES to a question the follow-up logic would direct which Data Entry screen/screens should be asked next or would terminate that line of questioning if no lower

```
BLOCK #7.149  MISCELLANEOUS SECTORS (TYPE 1)[ANY SECTOR]
SECTOR 200  REGION OF ILLNESS

   OWNER: HELP.PETER  SECURITY: AAAA  PRIORITY: 0
   ALWAYS SEND  DESTINATION LIST: TO PATIENT RECORD

   FINAL EVALUATIONS:
   A  VAL: (NOT(EX ITEM B AND EX ITEM C AND EX ITEM D AND EX ITEM H AND
     EX ITEM I AND EX ITEM J AND EX ITEM K AND EX ITEM L AND EX ITEM M)
     ) * 10

   SECTOR LOGIC:
   A  SEARCH:  (A) [FC], [ITEM] SEX (ID),  FROM: 0,  TO: NOW
   B  SEARCH: # (A) [FC] MISCELLANEOUS QUESTIONS, [N] THIS IS A COMPUTER
            PROGRAM DESIGNED TO ASK YOU ABOUT THE PROBLEMS THAT BRING
            YOU TO THE HOSPITAL. THE RESULTS ARE GIVEN TO YOUR
            PHYSICIAN. ARE YOU READY TO ANSWER SOME QUESTIONS ABOUT
            YOUR ILLNESS?, [ADJ] ARE YOU EXPECTING SURGERY DURING
            THIS HOSPITALIZATION?, [ADV] ARE YOU EXPECTING TO HAVE
            ABDOMINAL SURGERY?, (B) [ADV] ARE YOU EXPECTING TO HAVE
            CHEST, HEART OR LUNG SURGERY?, (C) [ADV] ARE YOU
            EXPECTING TO HAVE BONE OR JOINT SURGERY?, (D) [ADV] ARE
            YOU EXPECTING TO HAVE SURGERY FOR A SKIN PROBLEM?, (E)
            [ADV] ARE YOU EXPECTING TO HAVE THYROID, NECK OR HEAD
            SURGERY?
     FROM:  0,  IF ex: A OR B OR C OR D OR E
   C  SEARCH: # (A) [FC] MISCELLANEOUS QUESTIONS, [N] THIS IS A COMPUTER
            PROGRAM DESIGNED TO ASK YOU ABOUT THE PROBLEMS THAT BRING
            YOU TO THE HOSPITAL. THE RESULTS ARE GIVEN TO YOUR
            PHYSICIAN. ARE YOU READY TO ANSWER SOME QUESTIONS ABOUT
            YOUR ILLNESS?, [ADJ] HAVE YOU BEEN FEELING UNUSUALLY
            ANXIOUS OR DEPRESSED LATELY?
     FROM:  0,  IF ex: A
   D  SEARCH: # (A) [FC] MISCELLANEOUS QUESTIONS, [N] THIS IS A COMPUTER
            PROGRAM DESIGNED TO ASK YOU ABOUT THE PROBLEMS THAT BRING
            YOU TO THE HOSPITAL. THE RESULTS ARE GIVEN TO YOUR
            PHYSICIAN. ARE YOU READY TO ANSWER SOME QUESTIONS ABOUT
            YOUR ILLNESS?, [ADJ] IS YOUR MAIN PROBLEM WITH FATIGUE,
            WEAKNESS, OR GENERAL ACHING?
     FROM:  0,  IF ex: A
   E  SEARCH: # (A) [FC] MISCELLANEOUS QUESTIONS, [N] THIS IS A COMPUTER
            PROGRAM DESIGNED TO ASK YOU ABOUT THE PROBLEMS THAT BRING
            YOU TO THE HOSPITAL. THE RESULTS ARE GIVEN TO YOUR
            PHYSICIAN. ARE YOU READY TO ANSWER SOME QUESTIONS ABOUT
            YOUR ILLNESS?, [ADJ] ARE YOU HAVING A PROBLEM WITH YOUR
            GENITAL ORGANS?
     FROM:  0,  IF ex: A
   F  SEARCH: # (A) [FC] MISCELLANEOUS QUESTIONS, [N] THIS IS A COMPUTER
            PROGRAM DESIGNED TO ASK YOU ABOUT THE PROBLEMS THAT BRING
            YOU TO THE HOSPITAL. THE RESULTS ARE GIVEN TO YOUR
            PHYSICIAN. ARE YOU READY TO ANSWER SOME QUESTIONS ABOUT
            YOUR ILLNESS?, [ADJ] ARE YOU HAVING PROBLEMS WITH YOUR
            UTERUS, OVARIES, OR REPRODUCTIVE ORGANS?
     FROM:  0,  IF ex: A
   G  SEARCH: # (A) [FC] MISCELLANEOUS QUESTIONS, [N] THIS IS A COMPUTER
```

FIGURE 8. HELP Frame for the Region of Illness

PROGRAM DESIGNED TO ASK YOU ABOUT THE PROBLEMS THAT BRING YOU TO THE HOSPITAL. THE RESULTS ARE GIVEN TO YOUR PHYSICIAN. ARE YOU READY TO ANSWER SOME QUESTIONS ABOUT YOUR ILLNESS?, [ADJ] HAVE YOU HAD ANY PROBLEMS WITH EITHER BREAST?
FROM: 0, IF ex: A

H SEARCH: # (A) [FC] MISCELLANEOUS QUESTIONS, [N] THIS IS A COMPUTER PROGRAM DESIGNED TO ASK YOU ABOUT THE PROBLEMS THAT BRING YOU TO THE HOSPITAL. THE RESULTS ARE GIVEN TO YOUR PHYSICIAN. ARE YOU READY TO ANSWER SOME QUESTIONS ABOUT YOUR ILLNESS?, [ADJ] ARE YOU HAVING A PROBLEM WITH YOUR JOINTS, BONES, OR BACK?
FROM: 0, IF ex: A

I SEARCH: # (A) [FC] MISCELLANEOUS QUESTIONS, [N] THIS IS A COMPUTER PROGRAM DESIGNED TO ASK YOU ABOUT THE PROBLEMS THAT BRING YOU TO THE HOSPITAL. THE RESULTS ARE GIVEN TO YOUR PHYSICIAN. ARE YOU READY TO ANSWER SOME QUESTIONS ABOUT YOUR ILLNESS?, [ADJ] ARE YOU HAVING A PROBLEM WITH YOUR URINATION OR YOUR KIDNEY?
FROM: 0, IF ex: A

J SEARCH: # (A) [FC] MISCELLANEOUS QUESTIONS, [N] THIS IS A COMPUTER PROGRAM DESIGNED TO ASK YOU ABOUT THE PROBLEMS THAT BRING YOU TO THE HOSPITAL. THE RESULTS ARE GIVEN TO YOUR PHYSICIAN. ARE YOU READY TO ANSWER SOME QUESTIONS ABOUT YOUR ILLNESS?, [ADJ] ARE YOU HAVING PROBLEMS WITH YOUR ABDOMEN OR STOMACH?
FROM: 0, IF ex: A

K SEARCH: # (A) [FC] MISCELLANEOUS QUESTIONS, [N] THIS IS A COMPUTER PROGRAM DESIGNED TO ASK YOU ABOUT THE PROBLEMS THAT BRING YOU TO THE HOSPITAL. THE RESULTS ARE GIVEN TO YOUR PHYSICIAN. ARE YOU READY TO ANSWER SOME QUESTIONS ABOUT YOUR ILLNESS?, [ADJ] ARE YOU HAVING PROBLEMS WITH YOUR LUNGS, HEART, OR CHEST?
FROM: 0, IF ex: A

L SEARCH: # (A) [FC] MISCELLANEOUS QUESTIONS, [N] THIS IS A COMPUTER PROGRAM DESIGNED TO ASK YOU ABOUT THE PROBLEMS THAT BRING YOU TO THE HOSPITAL. THE RESULTS ARE GIVEN TO YOUR PHYSICIAN. ARE YOU READY TO ANSWER SOME QUESTIONS ABOUT YOUR ILLNESS?, [ADJ] ARE YOU HAVING PROBLEMS WITH YOUR EYES, EARS, NOSE, OR THROAT?
FROM: 0, IF ex: A

M SEARCH: # (A) [FC] MISCELLANEOUS QUESTIONS, [N] THIS IS A COMPUTER PROGRAM DESIGNED TO ASK YOU ABOUT THE PROBLEMS THAT BRING YOU TO THE HOSPITAL. THE RESULTS ARE GIVEN TO YOUR PHYSICIAN. ARE YOU READY TO ANSWER SOME QUESTIONS ABOUT YOUR ILLNESS?, [ADJ] ARE YOU HAVING A PROBLEM WITH YOUR HEAD OR NECK?
FROM: 0, IF ex: A

N SEARCH: (A) [FC] MISCELLANEOUS QUESTIONS, [N] WHAT IS YOUR AGE?
FROM: 0, IF ex: A

O EXIST: ASK((PATIENT QUESTIONS)B, C, D, H, I, J, K, L, M, N)

P EXIST: IF VAL ITEM A EQ "M"THEN ASK((PATIENT QUESTIONS)E)

Q EXIST: IF VAL ITEM A EQ "F"THEN ASK((PATIENT QUESTIONS)F, G)

FIGURE 8, Continued

level questions existed. A NO answer would end in termination of the branch or lead to a No User Entry question. The No User Entry question was transparent to the user placing NO answers in all questions beyond its origin in the branches of the tree. Using this structure all questions had a YES/NO answer .

The questionnaire contains 210 screens of which 88 are No User Entry screens. The questions were stored after each screen. The system did not let the patient change his mind on any question that had been stored. Every patient had to answer a minimum of 72 questions and there existed the possibility of answering a maximum of 348 questions for males or 359 questions for females.

To acquaint the patient with the computer, the questionnaire began by asking the patient's age, sex, and length of illness. Next, nine key system questions could then lead the patients into in-depth questioning of their illness. This was followed by 60 key general medical and personal history questions.

Report

In previous studies (5, 28) it has been shown the format of the physician's report is very important to computerized histories. The original report form for this project (Appendix A) would list patient's name and demographic information then give a review-of-systems from head to toe listing the lowest level answered for the YES questions (i.e., adjective, adverb) and the highest level(noun) for the NO answer. An attempt was made to develop a report that was formatted more closely to a physician's chart history and physical (Appendix B).

The report form begins with patient name, demographic information, and admitting diagnosis. This is followed by a chief complaint area. Since the admitting diagnosis is entered using freetext an algorithm had to be developed to decide the chief complaint. The simple scoring algorithm developed is to count the number of YES answers received in each system area, represented by one or more field codes in the PTXT code. Then the area with the most YES answers receives the highest score and is listed as the first chief

complaint area. In the report, the top three chief complaint areas are listed, giving the noun level, of the questions answered YES. Next a 'history of present illness' takes the chief complaint areas and lists the lowest level answered for the YES questions and the highest level answered for the NO questions under titles 'patient complains of:' and 'patient denies:' respectively.

The report then lists the affirmatively answered questions for the following sections: past medical history, medication history, allergy history, family history, social-occupational-travel history. This is followed by a review of system area. The review of systems area lists the lowest level questions answered YES to by field codes starting with a constitutional history, followed by each body area from head to toe ending with the neuropsychiatric area.

Collecting Patient Histories

To study the collection of patient histories, the decision was made to use one history for the first 20 patients collected then switch to the second method. The history was to be collect as part of the admission process. The patient histories were collected from the summer of 1985 through the summer of 1986.

With the DDA program running, we started to collect histories in July of 1985 on patients of nine surgery physicians in the multiphasic screening area. The multiphasic is an area where some patients stop, while being admitted to the hospital, for blood work, EKG, respiratory workup, etc. The personnel were instructed to notify the Medical Informatics department as the patients arrived and one of a group of research personnel would go to direct the computerized history. The patients were informed this was a research project and were given the option to take the computerized history. The person directing the history would startup the history program, show the patients how to enter their history into the computer system, and help infirm patients. Multiphasic used their own judgement on calling us if the patient was on a tight schedule with surgery, the patient was having another history taken, etc.

In an effort to increase experience with the system, I started to check the admission lists of the nine surgeons every morning and try to get histories on all new admissions by going to the patient on the floor using the rolling terminal. This had only a limited effect as most surgeons do same day admit and morning surgery. It was found if a history was taken after surgery, the patients complained of postsurgery problems even if asked to only describe presurgery conditions.

The short-stay surgery and A.M. admit surgery were contacted in an effort to interview their patients. Short-stay agreed to work with the research project. They would call Medical Biophysics as the patients arrived and we would go to their room with the rolling terminal and get the patient history. The biggest obstacle again was the time limitations. The patient was admitted, medicated, given a physical, history, X-rays, and then taken to surgery within a very short time frame. With A.M. admit the patients are processed in a large room, go directly to surgery, and are then placed in their private room. The A.M. admit area felt that because of the lack of privacy, they could not participate in the project.

Survey of Patients' Response to Computer History

The patient's reaction to the computerized history was collected as part of the study. A paper questionnaire was developed to evaluate the patient's reaction to the computerized history (Figure 9). The paper questionnaire was left with the patient to fill out after the computerized history and return to his nurse to send to the Medical Biophysics department.

The first five questions were to evaluate the patient's acceptance and comfort using the computer. The last five questions were directed at the patient's evaluation of the history questionnaire. The goal was to find if the computer took a thorough history and asked valid questions. This was used as a general test of acceptability of a computerized history, not as a comparative study between the branching questionnaire and the DDA questionnaire. More patients taking the branching questionnaire history answered the patient response questionnaire.

Name_____ Hospital Number_____ Date_____

Thank you for taking the patient computerized history. We would like your comments concerning the computer. Would you answer the following questions and return this questionnaire to your nurse. (Please Circle Your Answer)

1. Did you feel comfortable answering the questions? YES NO

2. Did you enyoy having your history taken by a computer? YES NO

3. Did you find the computer impersonal or unfriendly? YES NO

4. Did you find the computer difficult to use? YES NO

5. Did you find the computer easy to use? YES NO

6. Did the computer ask you about all your current health problems? YES NO

7. Did the computer ask you many questions that did not apply to you? YES NO

8. Would it help to have the computer explain some of the terms or questions in more detail? YES NO

9. Would you have liked "unknown" as a possible selection in addition to YES and NO? YES NO

10. In your opinion which took the more thorough history?

a. the computer
b. the physican
c. both the same

Please return this form to Dr. Haug
*Department of Medical Biophysics *

FIGURE 9. Patient Questionnaire on Computerized History Collection

Physicians' Response to the Computerized History

A copy of the computerized history was placed on the patient's chart within 24 hours. Another copy was sent through the mail to the patient's physician with a cover letter asking for comments on the validity, and completeness of the history.

CHAPTER 2

RESULTS AND EVALUATION

In the 12 months that data were gathered, 41 patients participated in the computer-directed history study. Of these 41 histories, 22 histories were taken in multiphasic screening, 17 used the rolling bedside terminals, and 2 histories were taken in short stay. Twenty-one patients used the hierarchical questionnaire and 20 patients took the DDA history. Three incomplete histories had to be excluded. Fourteen patients returned the paper questionnaire with their opinion of taking a computerized history.

As each patient history was taken the compter recorded the beginning time, ending time, and calculated the amount of time spent on the computer system. The number of questions the patient answered was also recorded. To examine the patient data there is a program that prints out the patient name, patient demographic information, the amount of time the history took, how many questions were answered YES, NO, the total number of questions asked, the diagnostic list generated for each patient with the top five disease states considered,the number of disease states considered, and the discharge diagnosis entered by Medical Records. The chief complaint was retrieved from a copy of the patient's history report.

Evaluation of the Amount of Time and the Number of Questions

The first variables to be evaluated were the number of questions asked and the length of time the hierarchical and DDA histories (Table 1). The hierarchical and DDA programs noted the begin and end time when they were run. The number of questions answered YES

and NO was calculated in a program to evaluate the data.

With the possibility of asking 359 questions, the DDA questionnaire asked a mean of 91 $\pm$ 31 (mean $\pm$ SD) questions with a range of 37 to152 questions asked to a single patient. The DDA history took an a mean time of 12 $\pm$ 5 minutes to complete with a range time of 4 to 28 minutes. The patients using the DDA history answered 37% of the questions asked YES . It took patients on average 7.9 $\pm$ 2.0 seconds to answer a question using the DDA questionnaire.

In contrast, patients taking the hierarchical history were asked a mean of 181 $\pm$ 26 questions with a range of 154 to 229 questions being asked a single patient. The hierarchical history had a mean time of 22 $\pm$ 10 minutes with a range of 9 to 51 minutes to complete with. The patients using the hierarchical questionnaire answered YES to 20% of the questions asked. It took a patient on average 7.3 $\pm$ 3.0 seconds to answer a question using the hierarchical history.

The T test was used to test if there was a significant difference in time and the number of questions asked with the hierarchical and the DDA questionnaire. It is shown there is a significant difference in the time used for the two histories ($p = 0.001$). There is also a significant difference between the number of questions asked by each questionnaire ($p < 0.001$). There is no significant difference between the number of questions answered YES to by the patients ($p = 0.659$). However, there is a significant difference between the number of questions asked that resulted in a NO response from the patients (hierarchical average 145 $\pm$ 16, DDA average 56 $\pm$ 15, $p < 0.001$).

Evaluation of the Accuracy

As an indicator of the accuracy of the history, the computer generated diagnosis list was compared to the discharge diagnosis in the patient's medical record (Table 2). While evaluating the 18 histories collected using DDA it was found , for seven of the discharge diagnosis, diagnostic frames did not exist. Accessing the remaining 11 DDA patients, five

TABLE 1. Time and Number of Questions for the Hierarchical and DDA Questionnaires

	Patients who used the Hierarchical Questionnaire	Patients who used the DDA Questionnaire
Number of patients	20	18
Number of Questions Asked*	181 ± 26	91 ± 31
Number of Questions Answered YES	35 ± 20	37 ± 19
Number of Questions Answered NO*	145 ± 16	56 ± 15
Amount of Time (minutes) *	22 ± 10	12 ± 5

* Significant difference between the Hierarchical Questionnaire and the DDA Questionnaire

TABLE 2. Comparison of the Discharge Diagnosis to the Diagnostic List and the Chief Complaint

	Patients who used the Hierarchical Questionnaire	Patients who used the DDA Questionnaire
Number of patients	20	18
Number of patients with diseases on the DD list	11	11
Number of Diseases[a] Captured in DD list	6 (55%)	5 (45%)
Number of patients with diseases in a CC area	18	15
Number of Diseases[b] Captured in CC area	11 (61%)	13 (87%)

DD = differential diagnostic list ; CC = Chief Complaint area;
a. Accuracy determined by the presence of the discharge diagnosis in the five member differential diagnostic list.

b. Accuracy determined by the presence of the discharge diagnosis within a Chief Complaint area.

(45%) of the discharge diagnoses were included on the computer generated diagnostic list of the five most probable disease states, and on six patients the discharge diagnosis was missing from the diagnostic list. On the 20 histories collected using the hierarchical method, nine disease states were not included in the diagnostic frames. Of the remaining 11 branching questionnaire patients, six (55%) of the discharge diagnoses were included on the computer generated diagnostic lists and the discharge diagnosis was not included in the diagnostic list with five patients. Using the Fisher exact test, there is not a significant difference (using $p<0.05$) between the hierarchical and DDA questionnaire when comparing the computer generated diagnostic list to the discharge diagnosis.

Another indicator of the accuracy is if the chief complaint area and the discharge diagnosis are in the same physiological system. This indicates the history questionnaire is asking questions about the correct body system. With the DDA method the chief complaint area was in the same region of illness as the discharge diagnosis 13 (87%) times, was missed twice, and could not be defined by the discharge diagnosis on three occasions. In the hierarchical questionnaire the discharge diagnosis was in the chief complaint area 11 (61%) times, was missed seven times and could not be defined using the diagnosis was in the chief complaint areas twice. Using the Fisher exact test there is not a significant difference (using $p<0.05$) between the hierarchical and DDA questionnaire, when comparing the chief complaint to the discharge diagnosis.

Patients' Response

Fourteen patients returned the paper questionnaire with their opinion of taking the computerized history. Table 3 is a summary of the response received from the patients.

Physicians' Comments

One of the six physicians whose patients used the computerized history returned three responses on physician report forms. The comments received dealt mainly with missing

TABLE 3. Patient Response to the Patient Questionnaire

PATIENT QUESTION	PATIENT RESPONSE	YES	NO
1. Did you feel comfortable answering the questions?		12	1
2. Did you enjoy having your history taken by a computer?		13	0
3. Did you find the computer impersonal or unfriendly?		3	10
4. Did you find the computer difficult to use?		1	12
5. Did you find the computer easy to use?		12	1
6. Did the computer ask you about all your current health problems?		2	11
7. Did the computer ask you many questions that did not apply to you?		10	2
8. Would it help to have the computer explain some of the terms or questions in more detail?		8	5
9. Would you have liked "unknown" as a possible selection in addition to YES and NO?		10	1
10. In your opinion which took the more thorough history?			
	a. the computer	1	
	b. the physician	5	
	c. both the same	7	

patient information usually missing information specific to the patient. Some of the comment received were missing allergies to specific drugs, not including a list of home medications, or not including information on patient social activities related to the illness (i.e., a physician commented that missing a patient's hobby of motorcycle riding was an important omission for a specific patient).

The other area of improvement suggested was in putting events in a time frame and quantitating events. An example of putting events in a time frame is to state at what age a patient goes though menopause or the time sequence of a series of events. The physician would also like to not only know that the patient has increased or decreased in an activity (i.e., bowel movements), but he would like to have the activity quantitated.

CHAPTER 4

CONCLUSION AND DISCUSSION

Discussion

The overall goal of this project was to compare two methods for entering a patient history into a computer system. Two comparable computerized patient history questionnaires were developed for the project. The histories were given to the patients. After collecting the patient histories, the following features were examined: the number of questions each history asked, the amount of time each history took, the accuracy of the history, and the patient reaction to using a computerized history. The best report format possible was designed for the physician's report. The physician's reaction to the history was requested.

The quantity of computerized histories collected and the response by the physicians fell short of the expectations. This failure was due in part to the fact that the computerized history was additional work for the patient, multiphasic screening, short stay and the physician. None of these groups of people received anything in return for their efforts. The computerized history only duplicated the other histories taken by the physician, medical house staff, and nursing personnel. The physician's computerized report was not made part of the patient's permanent record . The program was not attractive enough to the physicians, for the physicians to demand it be completed on all their patients.

In examining the number of questions each history asked and the amount of time each took, as stated earlier, it was found there was a significant difference between the DDA and hierarchical methods. The DDA took a mean time of 12 minutes and asked an average of 91 questions, while it only asked on average 56 NO response questions per patient. The

hierarchical method took a mean time of 22 minutes, asked an average of 181 questions, and asked an average of 145 NO response questions per patient. The reduction in the number of questions asked to the patient taking the DDA history is due to fewer number of NO response questions being asked (89 $\pm$ 15). It can infer not only NO answers to lower level questions after receiving response to higher level questions as the heirarchical questionnaire, but also only questions related to the patient's problem or symptoms. This is because the DDA asks only a set of questions related to a diagnostic hypotheses list of possible illnesses. By eliminating some patient questions unrelated to the patient's specific illness, and placing NO answers in logical questions (i.e., a patient who has said she had a hysterectomy or is 80 years old is not asked if she thinks she may be pregnant), the program not only reduces the amount of time the history takes but also eliminates the aggravation of the patient having to answer unnecessary questions. This reduces the burden to the patient and makes the history more manageable.

The quality or accuracy of a patient history is hard to evaluate. A history has to contain correct information, be organized in a logical fashion, be complete enough for the physician to make his diagnosis, but cannot contain too much miscellaneous information that obscures the patient's complaint. There is a fine line between relevant and irrelevant material included in a history. So as a method to evaluate a history, I decided to compare the computer generated diagnosis to the discharge diagnosis. This also has limitations. For 42% of the patients who took the history, there was not a help frame to diagnose the disease given in the discharge diagnosis. Because only a limited number of frames can be included in the program in its current form and people enter the hospital for a variety of reasons (e.g., one of the diagnoses that was not included on the list was electrical shock.) there will not always be a frame designed for each specific problem. Another limitation identified was that the diagnostic list of possible illnesses was only as good as the logic and bayesian statistics in the frames used. It has been shown (28) that improving the statistics used can increase the number of times the discharge diagnosis appears on the diagnostic list. For the 22 discharge

diagnoses where there was a frame availible, the program was correct 11 times or 50% (45% with the DDA, 55% with the hierarchical). It is felt the diagnostic list would include the discharge diagnosis more often if the frames were improved with new baysian statistics. There was no significant difference in having the discharge diagnosis on the diagnostic list between DDA and branching methods.

In taking the patient history the goal was to ask the patients in-depth questions in the area of their illness and try to avoid asking them a series of miscellaneous questions. The DDA, as part of its structure, tries to focus on the patient's illness and then ask only related questions. The design of the hierarchical questionnaire also tried to focus the questioning by asking where a patient's problem was and then keying off the patient's response. In comparing the chief complaint area obtained with the area of the chief complaint the discharge diagnosis fell, the program was correct 87% of the time with the DDA and 61% of the time with the hierarchical method. This shows that although the history only had the patient's discharge diagnosis on the history its diagnostic list 50% of the time, it was able to identify the area of the patient's major problem to focus its questioning.

In giving the patient history and examining the results, the following limitations of a YES/NO history questionnaire were observed. When the patient had more than one chief complaint area (e.g., the patient with the liver transplant) the questions would skip from one area to another, which was hard for some patients to follow. In some areas, such as home medications or place of employment, the variety of possible answers is almost impossible to include in a YES/NO selection. It was found hard to chronicle events in a patient's history with the YES/NO format. Another problem was when patients were in the middle of answering questions about their history, they would want to change answers to questions from five minutes earlier. It would have been nice to have a history review program set up for the patient at the end of the history.

The patient response was favorable to a computerized history. In examining the patients' reaction to using the computer in the first part of the patient questionnaire, the patients

answered they enjoyed having their history taken by the computer, felt it was easy to use, and friendly. The second half of the patient questionnaire asked questions about the patient history. The comment received most often was the computer asked the patients questions that did not apply to the patients (reply of 10 out of 12 patients) and the computer missed asking the patients about all of their current health problems (reply of 11 out of 13 patients). The patients would like to have the computer explain some questions in more detail (reply of 8 out of 13 patients). The patients also felt that a chance to answer "unknown" was important to them (reply of 10 out of 11 patients). The degree of acceptance of the computerized history was shown when 7 of the 13 patients who returned the history said the computer was as thorough as the physician.

It is disappointing that physicians did not express more of their reactions to the computerized history. This supports the results obtained by other researchers in this area (30).

Conclusion

In summary, the goal of obtaining a computerized history for a patient chart was achieved. It has been shown the DDA process took significantly less time and asked fewer questions then the hierarchical method, while maintaining the same level of accuracy. The patients' response to the computerized history was favorable.

The next step forward would be to allow a patient to enter some keyword answers into a DDA formatted program (e.g., drugs, employment). This would increase the range of information the history is able to collect. Another possibility would be to combine a hierarchically branching questionnaire with a DDA questionnaire. The hierarchical questionnaire would collect the demographic, past medical history, allergy, and medication history. This section could contain some screens where the patient could select from a multiple choice screen or enter a keyword. This would be followed by a DDA section that would collect the present illness history. The collection of present illness could then use not

only the chief complaint area to drive it but also use the past medical history information.

One factor is the nursing history being worked on currently. IThe nursing history could provide a wealth of information to drive the patient history questionnaire. But in order to fully utilize the new information in the database, the HELP diagnosis frames will have to be rethought. The existing HELP disease frames use broad general information to drive them to collect more detailed information. The HELP frames will have develop the capability to utilize the new detailed information in the data base to ask general questions along with some chief complaint questions.

APPENDIX A

OLD PHYSICIAN REPORT FORM

****
* COMPUTERIZED HISTORY *
****

TEST, HISTORY AGE: 36 ADMITTED: 11/24/86 13:17
PAT NUM: 4440 SEX: F ROOM: TEST
ATTENDING: WARNER, HOMER R. RAD NUM: 367123300

HISTORY COLLECTED ON MAR 17, 1987 13:38

********** CONSTITUTIONAL HISTORY ******

Patient Complains of:

OVER 10 LB WEIGHT LOSS,
RECENT WEIGHT LOSS,
DECREASED APPETITE,
FATIGUE INTERFERING WITH WORK,
RECENT AGITATION,
RECENT CHANGE IN WEIGHT OR APPETITE,
NIGHT SWEATS,
DURATION OF SYMPTOMS (DAYS),

Patient Denies:

HEAT INTOLERANCE,
COLD INTOLERANCE,
A TUMOR OR GROWTH,
LONG TERM WEIGHT LOSS,
INCREASED APPETITE,
RECENT WEIGHT GAIN,
BEING RECENTLY CONFINED TO BED,
MYALGIAS,
INCREASED THIRST,
FEVER,
CHILLS,

********** SKIN DISORDER HISTORY ******

Patient Denies:

A RASH,
PALE LIPS OR SKIN,
INCREASED FACIAL HAIR,
INCREASED PIGMENTATION,
RECENT JAUNDICE,
PRURITIS,
SUBCUTANEOUS LUMPS,
EASY BRUISING,
NEW SKIN GROWTHS,
POSSIBLE ERYTHEMA NODOSUM,

********** HEENT HISTORY ******

Patient Denies:

HEADACHE BEGINNING THE CURRENT ILLNESS,
RECURRING HEADACHES,
HEADACHE,
A CHANGE IN FACIAL APPEARANCE,
FACIAL PAIN,
INCREASED SENSITIVITY TO LIGHT,
THE USE OF GLASSES,
LOSS OF PERIPHERAL VISION,
RUNNY OR CONGESTED NOSE,
FREQUENT EPISTAXIS,
SNEEZING,
A RECENT TOOTH INFECTION,
EASILY BLEEDING GUMS,
A SWOLLEN, THICK OR SORE TONGUE,
PHARYNGITIS,
HOARSENESS OR A CHANGE IN THE VOICE,

********** CARDIOPULMONARY HISTORY ******

Patient Complains of:

CHEST PAIN, WITH NAUSEA,
CHEST PAIN, PAINFUL TO PALPATION,
CHEST PAIN, SUBSTERNAL,
CHEST PAIN, RADIATES TO SHOULDER, ARM, OR NECK,
EXERTIONAL CHEST PAIN,
PLEURITIC CHEST PAIN (WITH COUGHING),
CHEST PAIN, MADE WORSE BY EATING,
RECURRING EPISODES OF CHEST PAIN,
CURRENT CHEST PAIN,
BURNING CHEST PAIN,
ACUTE CHEST PAIN,
RAPID HEART RATE ACCOMPANIED BY SHORTNESS OF BREATH,
IRREGULAR OR RAPID HEART BEAT,

Patient Denies:

A CURRENT ASTHMA ATTACK,
DYSPNEA,
CHEST TIGHTNESS OR STUFFINESS,
RECENT WHEEZING,
CHEST PAIN RELIEVED BY REST,
CHEST PAIN, RELIEVED BY NITROGLYCERINE,
CHEST PAIN, RELIEVED BY SITTING UP/ LEANING FORWARD,
CHEST PAIN, RIGHT-SIDED,
CHEST PAIN, LEFT-SIDED,
CHEST PAIN, RADIATES TO BACK,
CHEST PAIN, INDUCED OR INCREASED BY BENDING/STOOPING,
CHEST PAIN, WORSE SUPINE,
CHEST PAIN, SQUEEZING/CONTRACTING,
PLEURITIC CHEST PAIN (WITH BREATHING),
RECENT COUGH,

********** BREAST HISTORY ******

Patient Denies:

ENLARGED OR ENGORGED BREASTS,
a Lump in the Breast,

********** GASTROINTESTINAL HISTORY ******

Patient Complains of:

3 NUMBER OF DAILY STOOLS,
DIARRHEA,
MELENA,
BLOODY STOOL,
FREQUENT HEARTBURN,
RECENT VOMITING, HEMATEMESIS,
HX OF RECENT NAUSEA,
ABD PAIN, RESOLVED BY VOMITING,
ABD PAIN, IMPROVED BY MILK/ANTACID,
ABD PAIN, DURATION LONGER THAN 30 MINUTES,
ABD PAIN, SEVERITY CAUSES DIAPHORESIS,
ABD PAIN, AGGRAVATED BY EATING,
ABD PAIN, IMPROVED BY EATING,
ABD PAIN, NOCTURNAL,
ABD PAIN, ACUTE,
ABD PAIN, EPIGASTRIC,
RED STREAKS ON TOILET PAPER,

Patient Denies:

CONSTIPATION,
DIARRHEA, AWAKENS PT DURING NIGHT,
CLAY COLORED STOOL,

DIARRHEA/CONSTIPATION ALTERNATING,
INCREASED FLATULANCE,
DYSPHAGIA,
ACID OR FOOD REGURGITATING UP INTO THE PHARYNX,
HX OF N/V, MOSTLY IN AM,
HX OF N/V, POSTPRANDIAL,
RECENT VOMITING, THROUGHOUT DAY INTERMITTENTLY,
RECENT VOMITING, BILIOUS,
ABD PAIN, WORSE WITH MOVEMENT OR COUGH,
ABD PAIN, MADE WORSE WITH BENDING,
ABD PAIN, INCREASED AFTER DEFECATION,
ABD PAIN, IMPROVED AFTER DEFECATION,
ABD PAIN, RADIATES TO BACK,
ABD PAIN, RECURRING,
ABD PAIN, SHARP OR CRAMPING,
ABD PAIN, BURNING,
ABD PAIN, RUQ,
ABD PAIN, HYPOGASTRIUM/SUPRAPUBIC,
ABD PAIN, RLQ (RIGHT LOWER QUADRANT),
ABD PAIN, LLQ (LEFT LOWER QUADRANT),
FULLNESS OR SWELLING IN ABDOMEN,

********** GENITAL-URINARY HISTORY ******

Patient Complains of:

FLANK PAIN,
IRREGULAR MENSTRUATION,

Patient Denies:

TESTICULAR PAIN, SWELLING, OR TENDERNESS,
RECENT PROBLEMS WITH URINATION,
URINE DISCOLORATION,
AMENORRHEA,
MENORRHAGIA,
DYSMENORRHEA,

********** OBSTETRIC HISTORY ******

Patient Denies:

A POSSIBLE CURRENT PREGNANCY,
A RECENT PREGNANCY,
A MISSED MENTRUAL PERIOD WITHIN 2 MONTHS,

********** MUSCULO-SKELETAL HISTORY ******

Patient Denies:

ARTHRALGIAS OR JOINT STIFFNESS,
RECENT LEG INJURY,

RAYNAUD'S PHENOMENON, FINGERS TURN WHITE AND PAINFUL IN COLD,
LEG/ANKLE EDEMA,
EDEMA, WARMTH OR TENDERNESS OF ONE LEG,
HISTORY OF VARICOSE VEINS IN LEGS,
BONE PAIN,
BACK PAIN,

********** ADENOPATHY HISTORY ******

Patient Denies:

SWOLLEN LYMPH NODES,
SWOLLEN LYMPH NODES,

********** NEURO-PSYCH HISTORY ******

Patient Complains of:

NERVOUS, TENSE, OR IRRITABLE RECENTLY,
STRESS/EMOTIONAL UPSET MAKE SYMPTOMS WORSE,

Patient Denies:

RECENT CONVULSION,
LOCALIZED MUSCLE WEAKNESS,
RECENT CHANGE IN SPEECH,
RECENT MEMORY LOSS,
RECENT SYNCOPE,
NUMBNESS,

********** PAST MEDICAL HISTORY ******

Patient has a History of:

HISTORY OF KIDNEY PROBLEMS,
GI DISORDER, HISTORY OF,
ULCER, HISTORY OF,
HISTORY OF HYPERTENSION,
PREVIOUS TRANFUSION,
HISTORY OF HEART FAILURE,
PRIOR MYOCARDIAL INFARCT,
RECENT CHEST X-RAY,
PRIOR NEOPLASM,

Patient Denies a History of:

HISTORY OF KIDNEY FAILURE,
GI DISORDER, ULCERATIVE COLITIS, HISTORY OF,
GI DISORDER, CHRON'S DISEASE, HISTORY OF,
GALLSTONES, HISTORY OF,
HISTORY OF CHRONIC LUNG DISEASE,
HISTORY OF TUBERCULOSIS,

WAS YOUR TRANSFUSION IN THE LAST SIX WEEKS?,
THROMBOPHEBILIS,
PULMONARY EMBOLI,
A SEIZURE,
HISTORY OF HEART MURMUR,
HISTORY OF ANGINA,
HISTORY OF DIABETES,
PRIOR CVA,
RECENT DENTAL WORK (WITHIN PAST TWO MONTHS),
RECENT CHEST X-RAY, ABNORMAL,
PRIOR TESTICULAR CANCER,
A PREVIOUS BREAST CANCER,
PRIOR NEOPLASIA, LYMPH NODE,
HISTORY OF LUNG CANCER,
HISTORY OF COLON CANCER,
HISTORY OF STOMACH CANCER,
PRIOR RENAL CANCER,
FREQUENT RESPIRATORY INFECTIONS,
ASTHMA,
HISTORY OF POSTIVE TB SKIN TEST,
HISTORY OF EXPOSURE TO TB,
PNEUMONIA,
HISTORY OF ECZEMA-LIKE RASH,

********** MEDICATION HISTORY ******

Patient is:

TAKING ANTIARRYTHMIC AGENT,

********** ALLERGY HISTORY ******

Patient Complains of:

PAST REACTION TO PENICILLIN,
ALLERGY TO VALIUM,
ALLERGY TO SURGICAL TAPE,

********** FAMILY HISTORY ******

Patient Complains of:

POSSIBLE EXPOSURE TO ILLNESS,

Patient Denies:

FAMILY MEMBER WITH HISTORY OF CANCER,
BLOOD RELATIVE WITH ULCERATIVE COLITIS,
FAMILY MEMBER WITH ALLERGIES/ECZEMA/OR ASTHMA,
POSSIBLE EXPOSURE TO "STOMACH FLU",
POSSIBLE EXPOSURE TO INFLUENZA,
BLOOD RELATIVE WITH DIABETES MELLITUS,

JEWISH ,

********** SOCIAL-OCCUPATIONAL-TRAVEL HISTORY ******

Patient Complains of:

ALCHOHOL ,
LIVES NEAR A MINE OR INDUSTRIAL AREA,
HAS VISITED SOUTH OR CENTRAL AMERICA RECENTLY,

Patient Denies:

RECENT HEAVY ETOH INTAKE,
POSITIVE HISTORY FOR SMOKING,
WORKED CLEANING (SCALING) BOILERS,
LIVED NEAR AN ASBESTOS FACTORY OR MINE,
WORKED AS A SHIPBUILDER OR IN A SHIPYARD,
WORKED WITH INSULATION,
WORKED WITH GASKETS, BRAKE LININGS, OR AUTO UNDERCOATING,
HISTORY OF EXPOSURE TO DUST OR FUMES,
MINE OR QUARRY WORKER,
WORKED MANUFACTURING GLASS,
HAS VISITED ASIA IN RECENT YEARS,

END REPORT

APPENDIX B

NEW PHYSICIAN REPORT FORM

****
* COMPUTERIZED HISTORY *
****

TEST, HISTORY AGE: 36 ADMITTED: 11/86 13:17
PAT NUM: 4440 SEX: F ROOM: TEST
ATTENDING: WARNER, HOMER R. RAD NUM: 367123300

ADMITTING DX:

HISTORY COLLECTED ON MAR 17, 1987 13:38

CHIEF COMPLAINT: 36 year old female complains of:

1) ABDOMINAL SURGERY,

2) 3 NUMBER OF DAILY STOOLS, RED STREAKS ON TOILET PAPER, A CHANGE IN STOOLS OR BOWEL HABITS, FREQUENT HEARTBURN, RECENT N/V, RECENT PAIN/TENDERNESS IN ABDOMEN,

3) RECENT CHEST PAIN, RAPID HEART BEAT, IRREGULAR OR RAPID HEART BEAT,

*** HISTORY OF PRESENT ILLNESS ***

PATIENT COMPLAINS OF THE FOLLOWING GASTROINTESTINAL SYMPTOMS:
3 NUMBER OF DAILY STOOLS, RED STREAKS ON TOILET PAPER, DIARRHEA, MELENA, BLOODY STOOL, FREQUENT HEARTBURN, RECENT VOMITING, HEMATEMESIS, HX OF RECENT NAUSEA, ABD PAIN, RESOLVED BY VOMITING, ABD PAIN, IMPROVED BY MILK/ANTACID, ABD PAIN, DURATION LONGER THAN 30 MINUTES, ABD PAIN, SEVERITY CAUSES DIAPHORESIS, ABD PAIN, AGGRAVATED BY EATING, ABD PAIN, IMPROVED BY EATING, ABD PAIN, NOCTURNAL, ABD PAIN, ACUTE, ABD PAIN, EPIGASTRIC,
PATIENT DENIES:
CONSTIPATION, DIARRHEA, AWAKENS PT DURING NIGHT, CLAY COLORED STOOL, DIARRHEA/CONSTIPATION ALTERNATING, INCREASED FLATULANCE, DYSPHAGIA, ACID OR FOOD REGURGITATING UP INTO THE PHARYNX, HX OF N/V, MOSTLY IN AM, HX OF N/V, POSTPRANDIAL, RECENT VOMITING, THROUGHOUT DAY INTERMITTENTLY, RECENT VOMITING, BILIOUS, ABD PAIN, WORSE WITH MOVEMENT OR COUGH, ABD PAIN, MADE WORSE WITH BENDING, ABD PAIN, INCREASED AFTER DEFECATION, ABD PAIN, IMPROVED AFTER DEFECATION, ABD PAIN, RADIATES TO BACK, ABD PAIN,

RECURRING, ABD PAIN, SHARP OR CRAMPING, ABD PAIN, BURNING, ABD PAIN, RUQ, ABD PAIN, HYPOGASTRIUM/SUPRAPUBIC, ABD PAIN, RLQ (RIGHT LOWER QUADRANT), ABD PAIN, LLQ (LEFT LOWER QUADRANT), FULLNESS OR SWELLING IN ABDOMEN,

PATIENT COMPLAINS OF THE FOLLOWING CARDIO-PULMONARY SYMPTOMS:
CHEST PAIN, WITH NAUSEA, CHEST PAIN, PAINFUL TO PALPATION, CHEST PAIN, SUBSTERNAL, CHEST PAIN, RADIATES TO SHOULDER, ARM, OR NECK, EXERTIONAL CHEST PAIN, PLEURITIC CHEST PAIN (WITH COUGHING), CHEST PAIN, MADE WORSE BY EATING, RECURRING EPISODES OF CHEST PAIN, CURRENT CHEST PAIN, BURNING CHEST PAIN, ACUTE CHEST PAIN, RAPID HEART RATE ACCOMPANIED BY SHORTNESS OF BREATH, IRREGULAR OR RAPID HEART BEAT,
PATIENT DENIES:
A CURRENT ASTHMA ATTACK, DYSPNEA, CHEST TIGHTNESS OR STUFFINESS, RECENT WHEEZING, CHEST PAIN RELIEVED BY REST, CHEST PAIN, RELIEVED BY NITROGLYCERINE, CHEST PAIN, RELIEVED BY SITTING UP/ LEANING FORWARD, CHEST PAIN, RIGHT-SIDED, CHEST PAIN, LEFT-SIDED, CHEST PAIN, RADIATES TO BACK, CHEST PAIN, INDUCED OR INCREASED BY BENDING/STOOPING, CHEST PAIN, WORSE SUPINE, CHEST PAIN, SQUEEZING/CONTRACTING, PLEURITIC CHEST PAIN (WITH BREATHING), RECENT COUGH,

****

---PAST MEDICAL HISTORY---
PATIENT HAS A HISTORY OF:
HISTORY OF KIDNEY PROBLEMS, GI DISORDER, HISTORY OF, ULCER, HISTORY OF, HISTORY OF HYPERTENSION, PREVIOUS TRANSFUSION, HISTORY OF HEART FAILURE, PRIOR MYOCARDIAL INFARCT, RECENT CHEST X-RAY, PRIOR NEOPLASM, ERROR T3,

---MEDICATION HISTORY---
PATIENT IS:
TAKING ANTIARRYTHMIC AGENT,

---ALLERGY HISTORY---
PATIENT COMPLAINS OF:
PAST REACTION TO PENICILLIN, ALLERGY TO VALIUM, ALLERGY TO SURGICAL TAPE,

---FAMILY HISTORY---
PATIENT COMPLAINS OF:
POSSIBLE EXPOSURE TO ILLNESS,

---SOCIAL-OCCUPATIONAL-TRAVEL HISTORY---
PATIENT COMPLAINS OF:
HAS VISITED SOUTH OR CENTRAL AMERICA RECENTLY, LIVES NEAR A MINE OR INDUSTRIAL AREA, ALCHOHOL ,

******* REVIEW OF SYSTEMS *******

---CONSTITUTIONAL HISTORY---
PATIENT COMPLAINS OF:
OVER 10 LB WEIGHT LOSS, RECENT WEIGHT LOSS, DECREASED APPETITE, FATIGUE INTERFERING WITH WORK, RECENT AGITATION, RECENT CHANGE IN WEIGHT OR

APPETITE, NIGHT SWEATS, DURATION OF SYMPTOMS (DAYS),

---SKIN DISORDER HISTORY---
NO POSITIVE SKIN DISORDER SYMPTOMS FOUND.

---HEAD HISTORY---
NO POSITIVE HEAD SYMPTOMS FOUND.

---EYES HISTORY---
NO POSITIVE EYE SYMPTOMS FOUND.

---ENT HISTORY---
NO POSITIVE ENT SYMPTOMS FOUND.

---NECK HISTORY---
NO POSITIVE NECK SYMPTOMS FOUND.

---URINARY HISTORY---
PATIENT COMPLAINS OF:
FLANK PAIN,

---JOINT HISTORY---
NO POSITIVE JOINT SYMPTOMS FOUND.

---EXTREMITIES HISTORY---
NO POSITIVE EXTREMITY SYMPTOMS FOUND.

---BACK HISTORY---
NO POSITIVE BACK SYMPTOMS FOUND.

---OBSTETRIC-GYNECOLOGY HISTORY---
PATIENT COMPLAINS OF:
IRREGULAR MENSTRUATION,

---ADENOPATHY HISTORY---
NO POSITIVE ADENOPATHY SYMPTOMS FOUND.

---NEURO-PSYCH HISTORY---
PATIENT COMPLAINS OF:
NERVOUS, TENSE, OR IRRITABLE RECENTLY, STRESS,AND EMOTIONAL UPSET MAKE SYMPTOMS WORSE,

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* NOTICE: This data sheet is part of an experimental academic *
* program based on computer responses to data on a patient answered *
* questionnaire; does not reflect professional medical diagnosis; *
* is not part of the patient medical record; and should be returned *
* to Dr. Peter Haug in the Biophysics Department upon the patient's *
* discharge. *
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REFERENCES

1. Bjerregaarg, B. et al., The Reliability of Medical History and Physical Examination in Patients with Acute Abdominal Pain. *Meth. Inform. Med.* 22: 15 (1983).

2. Mayne, J. G. Experiences with the Use of Automation for Collecting and Recording Medical-History Data. *Method. Inform. Med.* 8: 53 (1969).

3. Slack, W. V., Hicks, P. H., Reed,C. E., Cura , L. J. A Computer-Based Medical-History System. *New Engl. J. Med.* 247: 194 (1966).

4. Martin, J. M., Mayne, J. G., Taylor, W. F., Swenson, M. N. A Health Questionnaire Based on Paper-and- Pencil Medium Individualized and Produced by Computer. *JAMA* 208: 2064 (1969).

5. Haessler, H. A., Holland S., Elshtain, E. L. Evolution of an Automated Database History. *Arch. Intern. Med.* 134: 586 (1974).

6. Houziaux, M. O., Lefebvre, P. J. Historical and Methodological Aspects of Computer-Assisted Medical History-Taking. *Med. Inform.* 11: 129 (1986).

7. Blois, M. S. Clinical Judgment and Computers. *New Engl. J. Med.* 303: 192 (1980).

8. Weed, L. L. Medical Records that Guide and Teach. *New Engl. J. Med.* 278: 593 (1968).

9. Gordon, B. ed. "Current Medical Information and Terminologly." 4th ed. American Medical Association, Chicago, 1971.

10. Coombs, G. J., Murry ,W. M., Krahn, W. K. Automated Medical Histories: Factors Determining Patient Performance. *Comp. Biomed. Res.* 3: 178 (1970).

11. Collen, M. F. Patient Data Acquistion. *Med. Instrum.* 12: 222 (1978).

12. Grossmann, J. H., Barnett, G. O., McGuire, M. T., Swedlow, D. B. Evaluation of Computer-Acquired Patient Histories. *JAMA* 215: 1286 (1971).

13. Brodman, K., et al. The Cornell Medical Index: An Adjunct to Medical Interview. *JAMA* 140: 530 (1949).

14. Collen, M. F., et al. Reliability of a Self Administerered Medical Questionnaire. *Arch. Intern. Med.* 123: 664 (1969).

15. Mayne, J. G., Weksel, W., Sholtz, P. N. Toward Automating the Medical History. *Mayo Clin. Proc.* 43: 1 (1968).

16. Mayne G. M., et al. A Health Questionnaire Based of Paper-and-Paper Medium Individualized and Produced by Computer. *JAMA* 208: 2060 (1969).

17 Rockart J. F., McLean, E. R., Hershberg, P. I., Bell, G.O. An Automated Medical History System. *Arch. Intern. Med.* 132: 348 (1973).

18. Simmons, E. M., Miller, O. W. Automated Patient History-Taking. *Hospitals* 45: 56 (1971).

19. Warner, H. R., Rutherford B. D., Houtchens, B. A Sequential Bayesean Approach to History Taking and Diagnosis. *Comput. Biomed. Res.* 5: 256 (1972).

20. Pauker, G. P., Gorry, G. A., Kassirer, J. P., Schwartz, W. B. Towards the Simulation of Clinical Cognition: Taking a Present Illness by Computer. *Am. Journ. Med.* 60: 981 (1976).

21. Shortliffe, E. H., Davis, R., Axline, S. G., Buchanan, B. G., Green, C. C., Cohen, S. N. Computer-based Consultations in Clinical Therapeutics: Explanation and Rule Acquisition of the MYCIN System. *Comp. Biomed. Res.* 8: 303 (1975).

22. Miller, R. A., Pople, H. E., Myers, J. D. INTERNIST-1 An Experimental Computer-Based Diagnostic Consultant for General Internal Medicine. *New Engl. J. Med.* 307: 468 (1982).

23. Pryor, T. A., Gardner, R. M., Clayton, P. D., and Warner H. R. The HELP System. *J. Med. Systems.* 7: 87 (1983).

24. Warner, H. R. "Computer-Assisted Medical Decision-Making." Academic Press, New York, 1979.

25. Ledley, R. S., Lusted, L. B. Reasoning Foundations of Medical Diagnosis. *Science* 130: 9 (1959).

26. Gorry, G. A., Barnett , G. O. Experience with a Model of Sequential Diagnosis. *Comp. Biomed. Res.* 1: 490 (1968).

27. Haug, P. J.; Warner, H. R., Clayton P. D. A Decision-Driven System to Collect the Patient History. *Comp Biomed. Res.* 20: 193 (1987).

28. Lilfort, R. J., Glyn-Evans, D., Chard, T. The Use of a Patient-Interactive Microcomputer System to Obtain Histories in an Inferility and Gynecologic Endocrinology Clinic. *Am. J. Obstet. Gynecol.* 146: 374 (1983).

29. Shelton P. Analysis of the Information Content of Medical Data using a Frame-based Medical Diagnostic System. Unpublished Manuscript Department of Medical Informatics. University of Utah.

30. Anderson C. L. Techniques for Physician Review of Patient History Data in the HELP Computer System. Thesis University of Utah, December 1985.